The Build of A 4"X5" Full Movement Bellows View Camera

By James R. Kyle
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After building six “Sliding-Box” Cameras I thought it time that I build a true “full movement” bellows focusing view camera. I had ordered a replacement bellows for my Toyo 4X5 “Deluxe” monorail camera, however, upon receiving the bellows I found that it was for a “Horsemen” 4X5 camera and not the Toyo. (The seller did not know that the Horseman frames for the bellows would not fit a Toyo, so listed it would. And it was a very attractive price - $40.00). So, I made the decision to build another camera. Not a “simple camera”, as I have done with the Sliding-Box types, but a full movement view camera.

(*Italics* = Copied from The Toyo Web Page - Large Format Camera Technique)

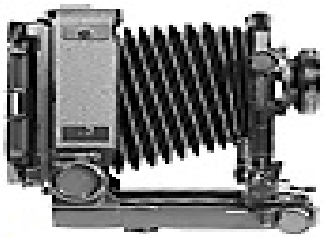
Movements

Photographers use view cameras to control focus and convergence of parallel lines. Image control is done by moving the front and/or rear standards. Movements are the ways the front and rear standards can move to alter perspective and focus. The term can also refer to the mechanisms on the standards that control their position.

Not all cameras have all movements available to both front and rear standards, and some cameras have more movements available than others. Some cameras have mechanisms that facilitate intricate movement combinations.

Some limited view camera–type movements are possible with SLR cameras using various tilt/shift lenses. Also, as use of view cameras declines in favor of digital photography, these movements are simulated using computer software.

Rise and fall



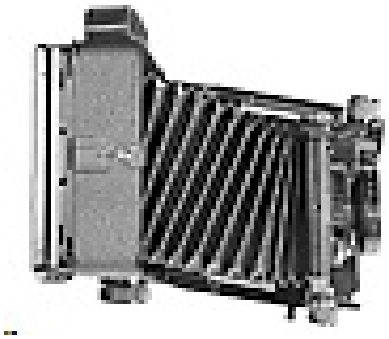
Rise and fall are the movements of either the front or rear standard vertically along a line in a plane parallel to the film (or sensor) plane. Rise is a very important movement especially in architectural photography. Generally, the lens is moved vertically - either up or down—along the lens plane to change the portion of the image captured on the film. In the 35 mm format, special shift lenses (sometimes called perspective control lenses) emulate the rise or fall of view cameras.

The main effect of rise is to eliminate converging parallels when photographing tall buildings. If a camera without movements is pointed at a tall building, the top is off. If the camera is tilted upwards to get it all in, the film plane is not parallel to the building, and the building seems narrower at the top than the bottom: lines that are parallel in the object converge in the image.

To avoid this apparent distortion, a wide-angle lens gets more of the building in, but includes more of the foreground and alters the perspective. A camera with rising front lets a normal lens be raised to include the top of the building without tilting the camera.

This requires that the image circle of the lens be larger than is required to cover the film without use of movements. If the lens can produce a circular image just large enough to cover the film, it can't cover the bottom of the film as it rises. Consequently, lens coverage must be larger to accommodate rises (and falls, and shifts).

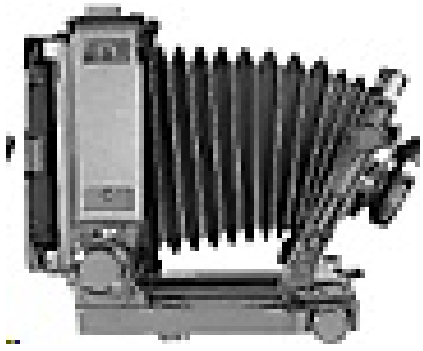
Front standard shift



Moving the front standard left or right from its normal position is called lens shift, or simply shift. This movement is similar to rise and fall, but moves the image horizontally rather than vertically. One use for shift is to remove the image of the camera from the final image when photographing a reflective surface.

Tilt

Front standard tilt



The axis of the lens is normally perpendicular to the film (or sensor). Changing the angle between axis and film by tilting the lens standard backwards or forwards is called lens tilt, or just tilt. Tilt is especially useful in landscape photography. By using the Scheimpflug principle, the “plane of sharp focus” can be changed so that any plane can be brought into sharp focus. When the film plane and lens plane are parallel as is the

case for most 35 mm cameras, the plane of sharp focus is also parallel to these two planes. If, however, the lens plane is tilted with respect to the film plane, the plane of sharp focus is also tilted according to geometrical and optical properties. The three planes intersect in a line below the camera for downward lens tilt. The tilted plane of sharp focus is useful, in that this plane can be made to coincide with a near and far object. Thus, both near and far objects on the plane are in focus.

This effect is often incorrectly thought of as increasing the depth of field. Depth of field depends on the focal length, aperture, and subject distance. As long as the photographer wants sharpness in a plane that is parallel to the film, tilt is of no use. However, tilt has a strong effect on the depth of field by drastically altering its shape, making it asymmetrical. Without tilt, the limits of near and far acceptable focus are parallel to the plane of sharp focus as well as parallel to the film. With forward tilt, the plane of sharp focus tilts even more and the near and far limits of acceptable focus form a wedge shape (viewed from the side). Thus, the lens still sees a cone shaped portion of whatever is in front of it while the wedge of acceptable focus is now more closely aligned with this cone. Therefore, depending on the shape of the subject, a wider aperture can be used, lessening concerns about camera stability due to slow shutter speed and diffraction due to too-small aperture.

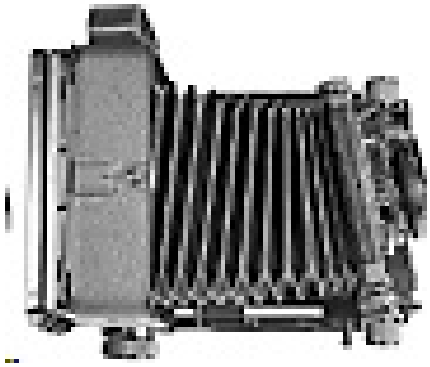
Tilting achieves the desired depth of field using the aperture at which the lens performs best. Too small an aperture risks losses to diffraction and camera/subject motion what is gained from depth of field. Only testing a given scene, or experience, shows whether tilting is better than leaving the standards neutral and relying on the aperture alone to achieve the desired depth of field. If the scene is sharp enough at f/32 with 2 degrees of tilt but would need f/64 with zero tilt, then tilt is the solution. If another scene would need f/45 with or without tilt, then nothing is gained. See Merklinger and Luong for extensive discussions on determining the optimal tilt (if any) in challenging situations.

With a forward tilt, the shape of the portion of a scene in acceptable focus is a wedge. Thus, the scene most likely to benefit from tilting is short in the front and expands to a greater height or thickness toward the horizon. A scene consisting of tall trees in the near, middle and far distance may not lend itself to tilting unless the photographer is willing to sacrifice either the top of the near trees and/or the bottom of the far trees.

Assuming lens axis front tilt, here are the trade offs in choosing between a small degree of tilt (say less than 3) and a larger tilt: A small tilt causes a wider or fatter wedge but one that is far off axis from the cone of light seen by the lens. Conversely, a large tilt (say 10 degrees) makes the wedge more aligned with the lens view, but with a narrower wedge. Thus, a modest tilt is often, or even usually, the best starting point. Small and medium format cameras have fixed bodies that do not allow for misalignment of the film and lens planes, intentionally or not.

Tilt/shift ("TS") or perspective control ("PC") lenses that provide limited movements for these cameras can be purchased from a number of lens makers. High-quality TS or PC lenses are expensive. The price of a new Canon TS-E or Nikon PC-E lens is comparable to that of a good used large-format camera, which offers a much greater range of adjustment.

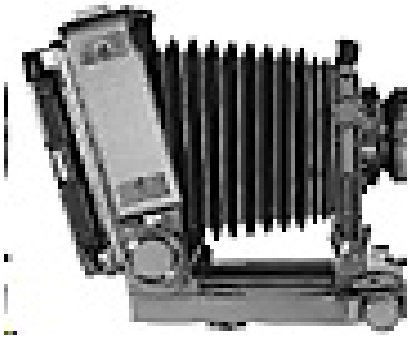
Swing

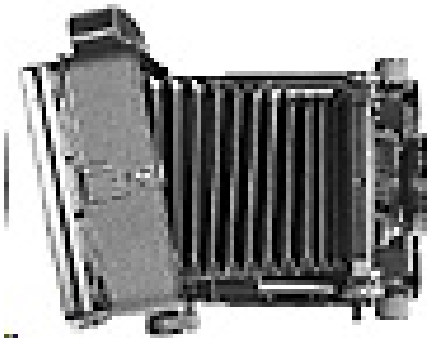


Front standard swing

Altering the angle of the lens standard in relation to the film plane by swiveling it from side to side is called swing. Swing is like tilt, but it changes the angle of the focal plane in the horizontal axis instead of the vertical axis. For example, swing can help achieve sharp focus along the entire length of a picket fence that is not parallel to the film plane.

Back tilt/swing





Angular movements of the rear standard change the angle between the lens plane and the film plane just as front standard angular movements do. Though rear standard tilt changes the plane of sharp focus in the same manner as front standard tilt, this is not usually the reason to use rear tilt/swing. When a lens is a certain distance (its focal length) away from the film, distant objects, such as faraway mountains, are in focus. Moving the lens farther from the film brings closer objects into focus. Tilting or swinging the film plane puts one side of the film farther from the lens than the center is and the opposite point of the film is therefore closer to the lens.

One reason to swing or tilt the rear standard is to keep the film plane parallel to the face of the subject. Another reason to swing or tilt the rear standard is to control apparent convergence of lines when shooting subjects at an angle.

It is often incorrectly stated that rear movements can be used to change perspective.[citation needed] The only thing that truly controls perspective is the location of the camera in relation to the objects in the frame. Rear movements can let a photographer shoot a subject from a perspective that puts the camera at an angle to the subject, yet still achieves parallel lines. Thus, rear movements allow a change of perspective by allowing a different camera location, yet no view camera movement actually alters perspective.

(The Italics Above = Copied from the Toyo Web Page - Large Format Camera Technique)

I always have to read over just how to apply the *"Scheimpflug principle*" every time I feel like making use of it. (Most landscape photography, that I do, does not require the use of it.)

Beginning the Build

As with most of the wooden things that I make, the use of a Table Saw is almost a must. As well as a Power Miter Saw, for cutting exact angles, small orbital sander, common miter box with hand saw, and a somewhat comfortable work area. The other tools are common household repair tools. (i.e. - screw drives, hacksaw, and the like). Sandpaper, wood stain (your choice), flat black spray paint, polyurethane, paint thinner, wood glue, rags, small paint brushes, wood clamps ("C"-clamps) and angle clamps.

The selection of wood materials will be up to you, the builder. I choose oak, for the standards and front and rear frames. For the camera bed I choose poplar as it is free of knots and a bit lighter. Also some 1/8 inch plywood (known as "underlayment".) Small wood screws, brass brads to secure the 1/8 inch plywood parts to the main body of the camera.

After measuring out all the main parts of the camera to be built, I like to lay them out in order of assemblage. (I design "On-The-Fly" as it were. I have a rough sketch of what I want with a few dimensions written on it, but that is about all I have - The rest is in my mind, or will present itself along the way.)

Being safe with ALL tools is something that I can not overly stress when building ANYTHING. Wear proper eye and ear protection (safety glasses and ear-plugs). The use of electrical powered tools will take "common sense" in the use thereof.

(***When using the table saw, count your fingers before cutting any of the wooden parts, especially when your fingers are in very close proximity of the revolving saw blade. And after - count them again, to make sure that all eight fingers and the two opposing thumbs are still attached. HEY! I am Serious. Nothing - I mean NOTHING - is as bad as a builder losing fingers - and it hurts like a bitch.***)

Flatbed Bellows 4X5
View Camera - Parts Layout

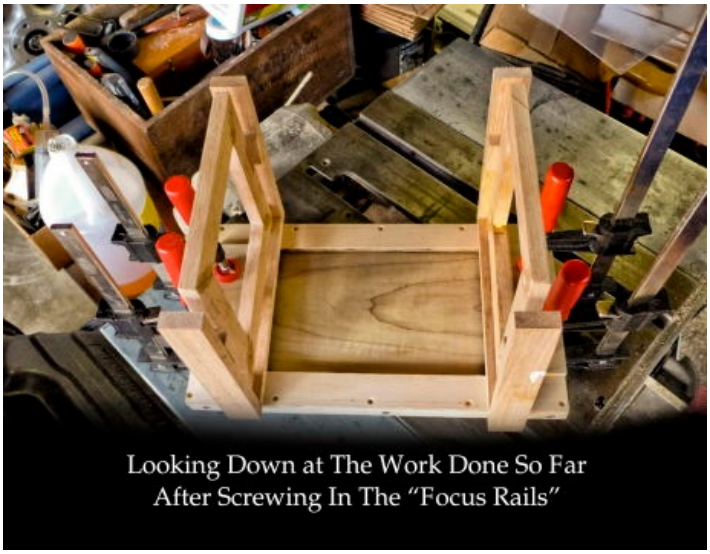
I cut all the major parts of the camera and lay them out - mainly to think what to do next. I decided to begin with the front and rear Up-Rights that will hold the standards. Using the table saw I cut the oak and poplar wood stock into the parts . Then cut the frames of the standards using the powered miter saw.

Now I can see the general shape of the camera before me, and I can proceed to the next phase of building.

Pre Assemblage - Flatbed Bellows 4X5
View Camera

With the standards glued I lay out the parts where they will be when the camera is built. The “Focusing Rail” of this particular 4X5 camera, is built onto the camera bed, or platform that will support the moving parts of the standards. These are all loose and not fitted together as yet.

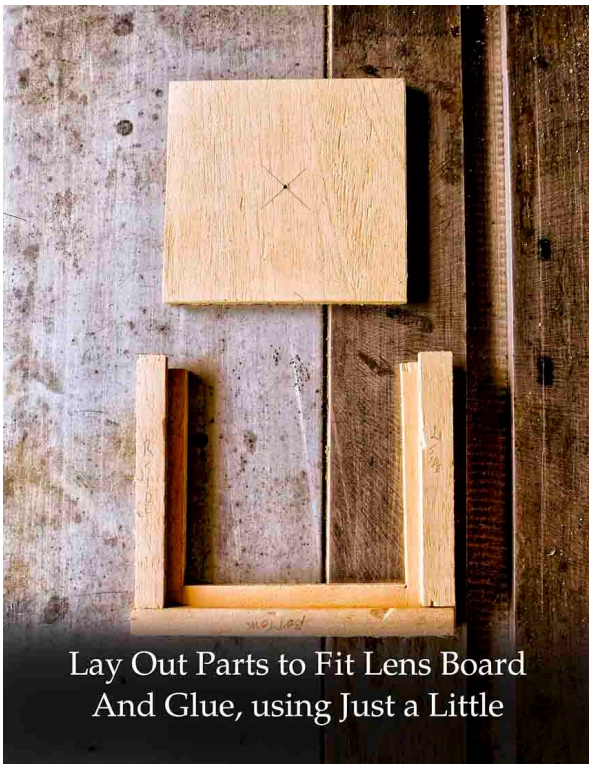
With the Up-Rights glued and secured with #6 Phillips wood screws, and the bed with the focus-rails lined up - but not secured in place - I get a good idea as to how the parts are coming together.



Looking Down at The Work Done So Far
After Screwing In The "Focus Rails"

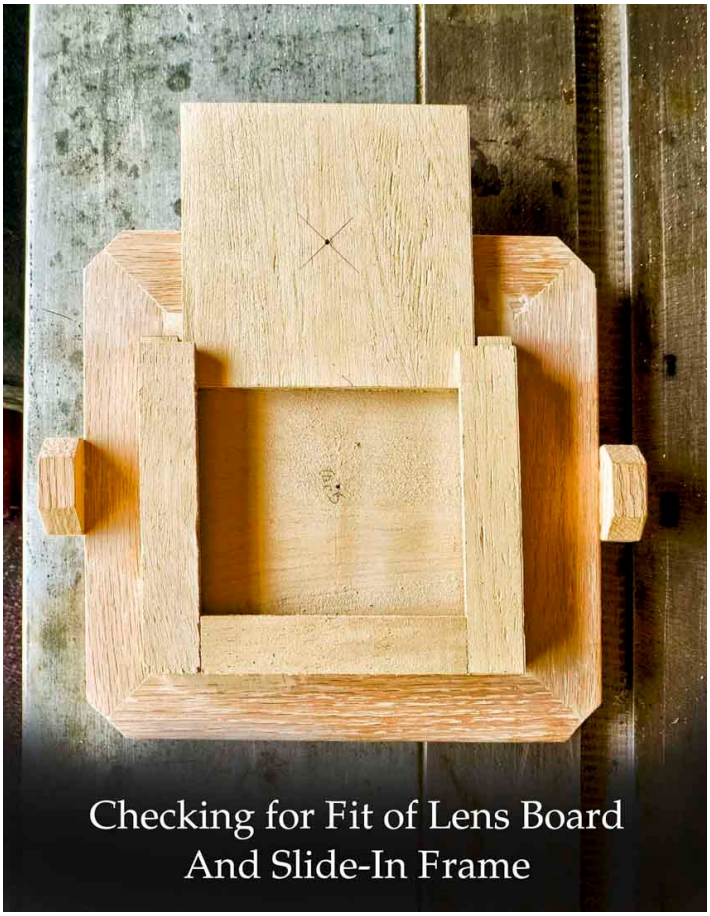
With the glue curing I can concentrate on the details of the Front Standard and the Lens Board. (This holds the lens to the front standard and with "Slide-In" slots will make it easy for the changes of lenses.)

Cut To Size Lens Board to Fit Front Standard

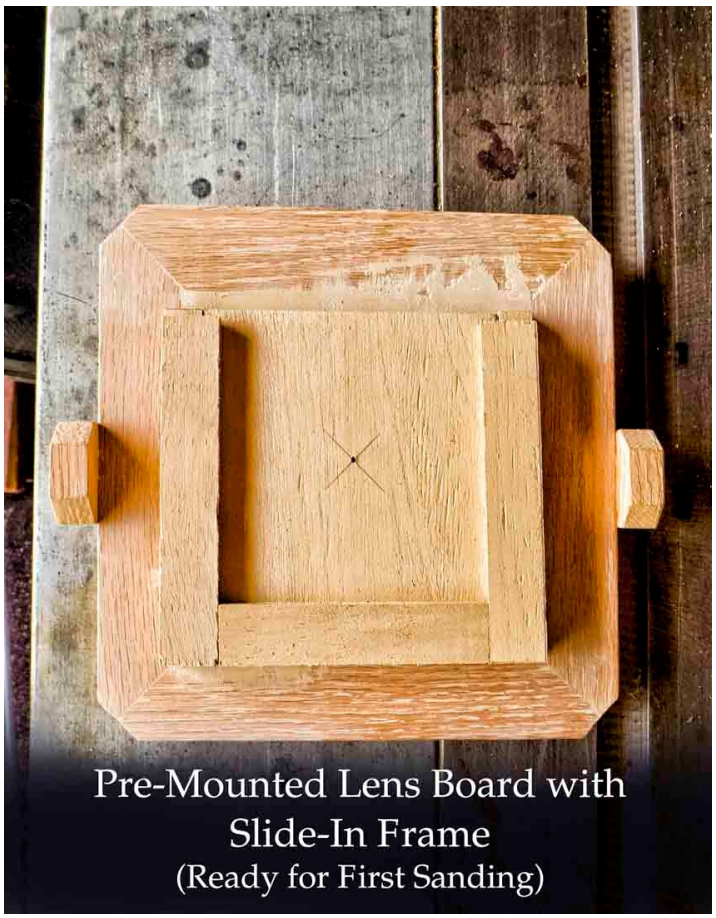


Lay Out Parts to Fit Lens Board
And Glue, using Just a Little

After Cutting and Fitting the Lens Board
Sliding Frame Glue All the Parts Together



Checking for Fit of Lens Board
And Slide-In Frame

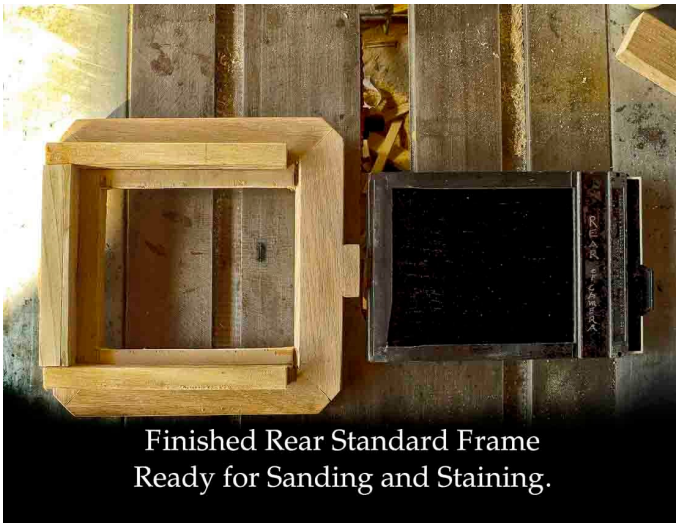


Pre-Mounted Lens Board with
Slide-In Frame
(Ready for First Sanding)

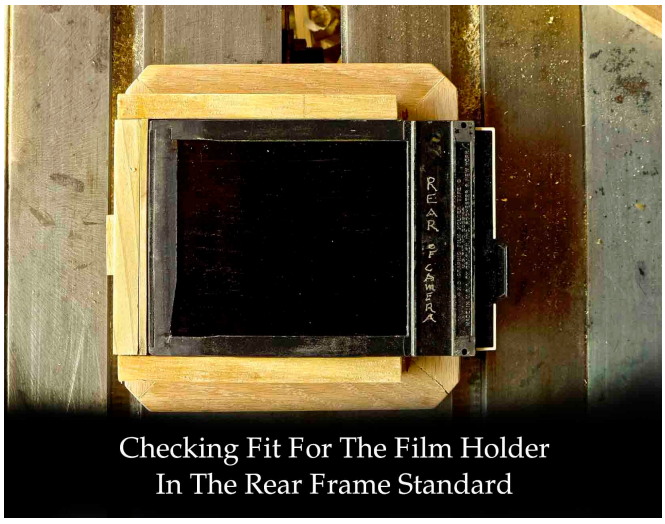
Finished Front Standard and Forward Frame
And Lens Board - Sanded Stained and Ready.

Front Standard Frame and Lens Board
Stained and Ready to Mount on Forward Up-Right

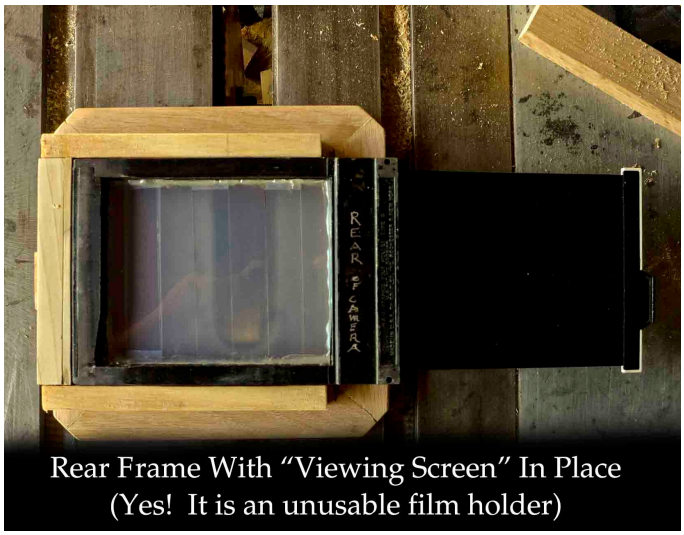
Now comes the time to concentrate on the Front and Rear Standard Frames. These standards are the heart of any full movement view camera, and reside on each end of the focusing bellows. The Front standard holds the Lens, in a Lens Board. The Rear supports the “Ground Glass” viewing area, and the Film Holder. These standards are supported by Up-Rights that move along the Flat Bed, and are allowed to “Shift” and Pivot along the “X” axis of both up-right standard supports. The focus is attained by the movement of the front, and or, rear standards away from each other. The closer the subject the further the distance from each of the standards.



Finished Rear Standard Frame
Ready for Sanding and Staining.



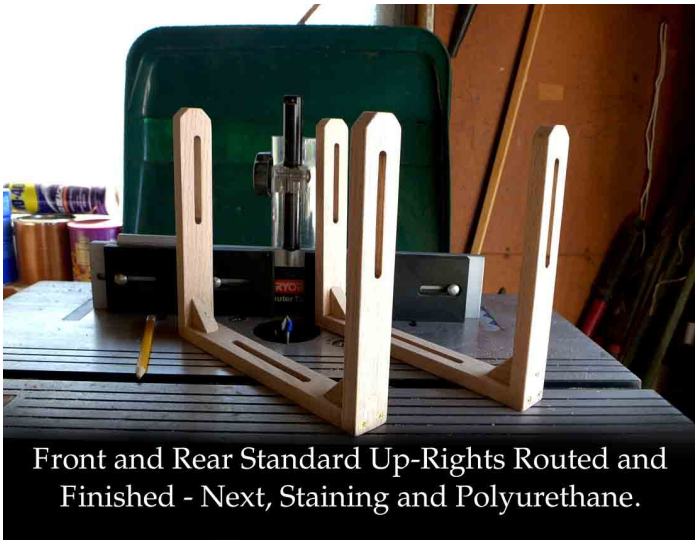
Checking Fit For The Film Holder
In The Rear Frame Standard



Rear Frame With "Viewing Screen" In Place
(Yes! It is an unusable film holder)

The Up-Right supports now must be attended to for the cutting of the "Rise and Fall" movement Slots, and Shift Pivots. And the Slot for the Pivots for the bottom of the up-rights, in that the movements of the Shift are done with ease of operation. This is done with a power router. The router has different attachable tool cutting bits that may be used to make different cut for the removable of a selected amount of wood that the builder wish to be removed. This was my first time I used a router - I bought it several years ago on the thought of building some kitchen cabinets. However, as things turned out, I did not do that build. Thank goodness for YouTube VIDs.

The next step, after the roughing of the "Movement Slots", of the build was to sand, stain and lay down the first coat of polyurethane. (After each coat, I use a "Scotch-Brite" to rough-up the preceding coat. I usually give three coats of polyurethane on any wooden project build that would require me to do so.) Between coats, I also wipe down with paint thinner, to remove dust that collects in the grain of the wood after the Scotch Brite rub-down before applying the next coat.

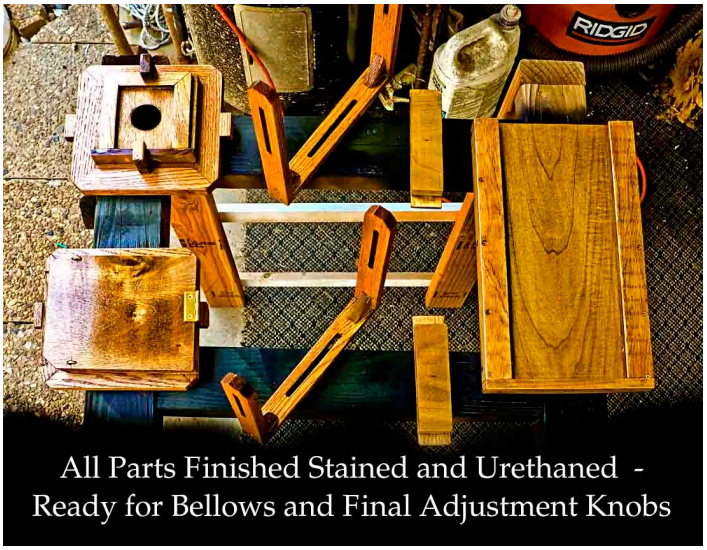


Front and Rear Standard Up-Rights Routed and Finished - Next, Staining and Polyurethane.

Rear Frame Standard Complete

As like the build of my cameras before this one, I used the same Rear Standard “Ground Glass” mounting. (A “Frosted Taped” 4X5 inch sheet of Plexiglas held in an old, not usable for anything else, 4X5 Film Holder.) A hinged door on the back that would hold film holders securely in place and as well as keep out “light-leaks” from entering the focal plan area.

Rear Frame Standard Complete
Ready for Stain And finish Polyurethane



All Parts Finished Stained and Urethaned -
Ready for Bellows and Final Adjustment Knobs

The selection of the Movement “Locking Knobs” was found at a local “Ace Hardware” store. One quarter of an inch brass threaded “Tri-Cornered” Black knobs. The one quarter inch threaded stock was cut to fit the width of the “up-rights” of the front and rear standards, and epoxied into the up-rights, forward and rear Pivots. (These move from Left to Right and are “parked” in the center when the camera is being transported.)

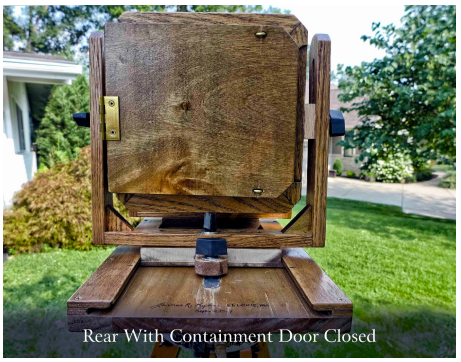
After the final assemblage, I made some test exposures to check for light leaks. None being found from these test I mounted a 1/4"-20 T.P.I. Tripod Mounting trunion to the bottom of the “bed” of the camera. I then mounted the finished camera on a tripod.

Here are the final photos of this Total Movement 4X5 Flatbed Camera.

Flatbed Total Movment 4X5 Camera Finished

Front View

Left Side View


Rear With Containment Door Closed

If you feel that the design of this camera will not suit your photographic work - Please feel free to make any and all of your improvements to make it so.
As with anything that I build and show others, it is totally up to them to make changes as to how the finished outcome will work, and work comfortably for you.
This is only a guide for a build. James R. Kyle.